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ABSTRACT

The electrical activity of the abdominal muscles was tested during situps to determine the effect upon integrated muscle action potential (MAP). The following types of situps were used in testing 18 college males: (1) trunk curls; (2) AAHPER situp; (3) YMCA situp; (4) modified AAHPER situp; and (5) modified YMCA situp. All situps were performed with the fingers interlocked behind the head and with the knees bent. Findings indicated that altering the YMCA and AAHPER situps so that the feet are not anchored resulted in a significant reduction in MAP's of the abdominal musculature. Also, elimination of the hip flexion portion of the trunk curl situp resulted in diminished electrical activity of the external oblique muscles. (JD)

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Effects of Various Types of Situps on Integrated MAP's of the Abdominal Musculature

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Running head: Situps and Integrated MAPS' of Abdominal Musculature

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Abstract

Eighteen college male volunteers aged 19 to 24 years were used as subjects. The electrical activity of the upper rectus abdominis, lower rectus abdominis, and external oblique muscles was monitored, amplified, and integrated while performing six repetitions of each type of the following types of situps: (1) trunk curls, (2) AAHPER situp, (3) YMCA situp, (4) modified AAHPER situp, and (5) modified YMCA situp. All situps were performed with the fingers interlocked behind the head and with the knees bent. Area under the curve summation was accomplished with a general purpose integrator while each subject performed six repetitions of each type of situp. A 5 x 18 (muscle by subject) analysis of covariance design was used in conjunction with four planned comparisons among treatments with the time required to complete each method used as the covariate. Findings indicated that altering the YMCA and AAHPER situps so that the feet are not anchored resulted in a significant reduction in MAP's of the abdominal musculature. Also, elimination of the hip flexion portion of the situp (trunk curl) resulted in diminished electrical activity of the external oblique.

Effects of Various Types of Situps on Integrated MAP's of the Abdominal Musculature

For many years some form of situps has been used as a test for abdominal muscular endurance. One of the most often-used forms is with the feet anchored, knees bent, and fingers interlocked behind the head, and touching the elbow to the opposite knee (Myers and others, 1973). This form has been used by the YMCA's and in adult fitness testing centers throughout the country for several years. The AAHPER recommends a variation of this test whereby the twist at the top of each repetition is not included and the sides of the elbows must touch the floor on each repetition (AAHPER, 1975)

Results of several electromyographic investigations indicate that a situp test may more accurately assess the endurance of the entire abdominal musculature if the feet are not anchored (Walters and Partridge, 1957; Flint, 1965; Bernard and Lipetz, 1971) and if trunk rotation is involved (Partridge and Walters, 1959; Flint, 1965a). A modification of the situp test eliminating the trunk flexion portion of the movement (trunk curl) has also been proposed as a result of electromyographic observations (Partridge and Walters, 1959; Flint, 1965a). A more recent study found the truncated form of situps (trunk curl) to elicit action potentials of lesser magnitude than did other abdominal exercises; however, in this study, hands were placed at the sides, thereby lessening the resistance provided by the upper extremity (Gutin and Lipetz, 1971).

In an effort to develop a more valid test of abdominal muscular endurance, Noble (1975) proposed the use of a trunk curl test involving a trunk twist, with the feet not anchored, and with the fingers interlocked

behind the head. This test was shown to have acceptable reliability and objectivity; however, evidence of improved abdominal muscular involvement was lacking.

The electromyographic studies involving the function of the abdominal musculature are characterized by the use of a few, well-trained subjects and qualitative data analysis techniques. These shortcomings greatly limit the validity and extensibility of the results.

The purpose of this study was to compare integrated muscle action potentials of the upper rectus abdominis, lower rectus abdomonis, and external oblique muscles during performance of various types of situps. The relative effects of the AAHPER and YMCA situps were determined and the effect of modifying these methods by eliminating anchoring the feet was studied. Also, the effect of truncating the YMCA situp to eliminate hip flexion (i.e., trunk curl) was determined.

Procedures

Eighteen college male volunteers ranging in age from 19 to 24 years ($\bar{x}$ = 21.6) participated in the study. All subjects had abdominal skinfolds less than 2.5 cm. Accurate electrode placement was not difficult because each subject had well-defined abdominal musculature. Surface electrodes 11mm in diameter were secured to the skin with self-adhesive double-sided washers. The electrode site was prepared by shaving all hair and rubbing vigorously with a towel that had been saturated with alcohol. Continuous skin contact was ensured by using electrode paste to fill the space between the electrode and the skin. All electrodes were placed on the right side of the subject.

Two electrodes for monitoring the upper rectus abdominis were placed to the right of the midline over the center of the second segment superior to the umbilicus. Electrodes were also placed over the center of the lower right abdominal segment. The site for monitoring activity of the right external oblique was directly over the center of the muscle with the two electrodes directed diagonally medialward and downward, coinciding with the direction of the fibers. The distance between the contact surface of each pair of electrodes was 2.5 cm. A ground electrode was attached laterally over the iliac crest. Figure 1 indicates the approximate location of the electrodes.

Insert Figure 1 about here

The electrical activity of the muscle was channelled into appropriate amplifiers and a penwriting device distributed by Narco-Bio Systems, Inc. The direct signal was recorded and monitored to determine signal quality and was simultaneously routed through a Model GPA-10 Integrator, manufactured by Narco-Bio Systems, Inc., and recorded. This is a general purpose integrator which quantitatively gives area under the curve summation.

Recordings of the direct and integrated signals from each of the three muscle sites were made simultaneously while the subject performed 6 repetitions of situps using five different methods. Descriptions of the five situp methods are as follows:

Trunk Curls. Knees are flexed so that the heels are approximately 18 ins. from the buttocks, the feet are not anchored and flat on the floor. The hands are placed behind the head with the fingers interlaced. A cardboard, cut out to fit around the body of the subject, is held over the abdomen at the level of the umbilicus and perpendicular to the floor. The subject raises the shoulders from the floor, twists the trunk and touches the left side of the cardboard with the right elbow. On the return movement, the knuckles must touch the floor and body momentum must be broken with a slight hesitation. Continue, alternating touching right and left sides of the cardboard with the elbows.

AAHPER Situp. This situp is performed identical to the method described in the AAHPER Youth Fitness Test Manual (AAHPER, 1975). The knees are flexed so that the heels are within one foot of the buttocks. Fingers are clasped behind the neck and the feet are held down by the tester. The subject then sits up and touches the elbows to the knees. On the return movement, the elbows must touch the floor before repeating.

YMCA Situp. This situp is performed identical to the method described by Myers and others (1973). The knees are flexed so that the heels are approximately 18 ins. from the buttocks, fingers are interlaced behind the neck, and the feet are held down. The subject sits up and touches the left knee with the right elbow. On the return movement, the knuckles must touch the floor. Continue, alternating touching right and left knees with the elbows.

Modified AAHPER Situp. Identical to the AAHPER situp except the feet are not held down.

Modified YMCA Situp. Identical to the YMCA situp except the feet are not held down.

Testing Protocol

On each testing session, the subject reported wearing only athletic shorts. After the electrode sites were selected and prepared and the electrodes attached, the subject assumed a supine position and sample recordings were taken. If the quality of the tracings was acceptable, the subject was given instructions on how to do each exercise. Six repetitions of each method were then performed at a moderate rate whiel action potentials were recorded. A one-minute rest was given between each method and the order of performance of each was rotated using a latin square.

Statistical Method

Recordings were first checked for quality and, if no artifact or other problems were present, measurements were made of the height of each integrated channel for each muscle at the end of each method. These measurements were made with a plastic overlay accurate to within .5mm. Also, the duration of each method was recorded to the nearest .1 sec. The integrated activity for each treatment was compared using covariance analysis with the effect of duration of the condition removed. A 5 x 18 (treatment by subject) analysis of covariance was computed for each muscle with duration being the covariate. The adjustment for the effect of time was done to more accurately reflect intensity of electrical activity. The following specific comparisons among groups were planned: (1) YMCA

method vs. AAHPER method, (2) modified YMCA method vs. modified AAHPER method, (3) AAHPER and YMCA method vs. modified AAHPER and modified YMCA methods, and (4) trunk curl vs. modified YMCA method. One-tailed probabilities were used in comparisons when an outcome of a specified direction was reasonably expected from reviewing the related literature.

Results

Means and standard deviations for integrated MAP's and for each muscle as well as for elapsed time are given for each condition in Table 1. The assumptions of homogeneity of variance of adjusted scores and homogeneity of within group regression lines which are associated with the covariance analysis were found to be tenable. The correlation coefficients between time and MAP's for each condition were .33, .49, and .57 for the upper rectus abdominis, lower rectus abdominis, and external oblique, respectively.

Insert Table 1 and Table 2 about here

Table 2 gives the adjusted means and standard errors of the adjusted means for each method for each muscle obtained from the analysis of covariance. These represent the summated muscle action potentials with the effect of duration of method removed. The results of the planned comparisons for each muscle are presented in Table 3. Significant t-ratios were found for the third comparison (AAHPER and YMCA methods vs. modified AAHPER and modified YMCA methods) for all three muscles with the modified methods yielding greater MAP's. All other comparisons for

the upper and lower rectus abdominis muscles were insignificant. Comparisons 1 (AAHPER method vs. YMCA method) and 4 (trunk curl vs. modified YMCA method) yielded significant differences for the external oblique with the YMCA method yielding greater MAP's than the AAHPER method and the trunk curl yielding lesser MAP's than the modified YMCA method.

Insert Table 3 about here

Discussion

The significant finding for comparison 3 supports the hypothesis that doing situps with the feet not anchored elicits greater electrical activity of the abdominal musculature than doing them with the feet anchored. This result supports the findings of other studies (Flint, 1965b; Walters and Partridge, 1957), but is in conflict with the conclusions of Flint (1965a) who reported greater MAP's from the lower rectus abdominis when the feet were anchored. It is noteworthy that all of these previous studies used qualitative data analysis, a very small sample size (from 2 to 10), and all of the subjects were trained females. These differences could account for the contradictory results.

The upper and lower rectus abdominal muscles were not differentially affected by the methods involved in comparison 1; however, a significant effect on the external oblique was found. The essential difference between these two methods was the involvement of a trunk twist at the end of the

upward movement in the YMCA method. These findings are in support of previous research establishing the increased involvement of the external oblique in exercises incorporating a trunk twist (Walters and Partridge, 1957). However, this effect appears to be operative only when the feet are anchored, as indicated by the insignificant findings resulting from comparison 3.

Comparison 4 was made to determine the effect of truncating the situp to eliminate hip flexion, as suggested by Soderberg (1966). The two methods involved in this comparison were identical in all other respects. The results indicated that both sections of the rectus abdominis muscle were not affected by truncating the movement but the MAP's of the external oblique were significantly diminished. This finding is contradictory to that of Partridge and Walters (1959). Again, the apparently contradictory results could possibly be because of the differences in the subjects used in these studies, specifically with respect to training and gender.

It is interesting to note that modification of the two commonly used methods of testing situps (AAHPER and YMCA) to eliminate anchoring of the feet resulted in greatly increased electrical activity of both the upper and lower sections of the rectus abdominis as well as the external oblique. It appears that if these conventional fitness test items were modified so that the feet were not held down a more valid test of the abdominal musculature would result.

After reviewing several electromyographic studies, Soderberg (1965) strongly suggested that the AAHPER Youth Fitness Tests should be modified to eliminate the hip flexion portion of the movement in an effort to make the test more valid. No support for this suggestion was found in this study.

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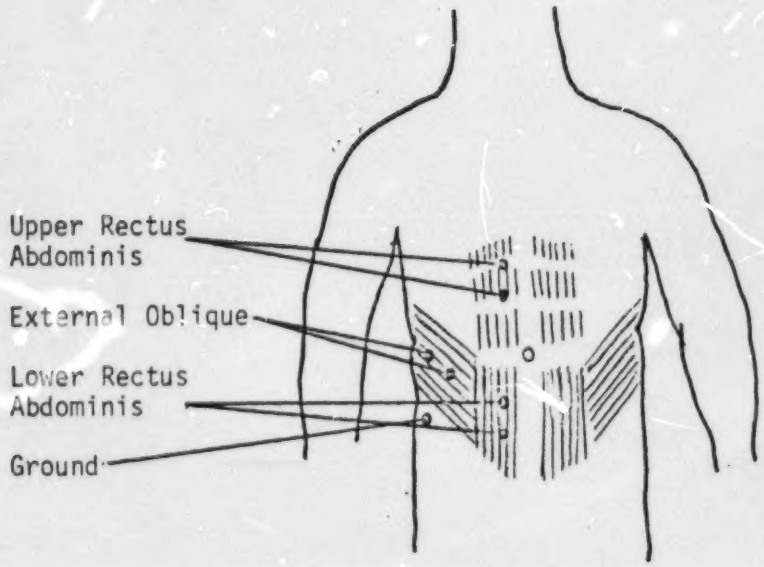

Figure 1. Electrode Placement

Situps

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TABLE 1

Group Means and Standard Deviations*

Method	Upper Rectus Abd.	Lower Rectus Abd.	External Oblique	Time
Trunk Curl	15.021±8.265	11.347±.7.091	3.395±2.360	62.389±15.647
AAHPER Situp	14.287±.8.745	10.353±.5.708	3.415±1.813	77.750±16.462
YMCA Situp	14.476±8.626	9.618±5.942	3.833±1.965	71.778±15.071
Modified AAHPER Situp	17.019±10.381	15.362±9.880	6.425±3.381	84.562±17.370
Modified YMCA Situp	15.865±9.066	13.065±8.669	5.800±3.017	76.235±17.232

*All scores are in millimeters of pen deflection.

TABLE 2

Adjusted Means and Standard Errors*

Method	Upper Rectus Abd.	Lower Rectus Abd.	External Oblique
1. Trunk Curl	16.469±.907	11.396±1.009	4.198±.359
2. AAHPER Situp	14.472±.831	10.045±.925	3.324±.330
3. YMCA Situp	15.000±.797	9.855±.887	4.154±.304
4. Modified AAHPER Situp	16.088±.892	14.224±.993	5.569±.352
5. Modified YMCA Situp	16.456±.809	12.852±.901	5.597±.308

*All scores are in millimeters of pen deflection.

TABLE 3

Chance Probability of Planned Comparisons Among Methods

Groups Compared	Variable		
	Upper Rectus Abd.	Lower Pectus Abd.	External Oblique
2 vs. 3	NS	NS	<.05[a]
4 vs. 5	NS	NS	NS[a]
2,3, vs. 4,5	<.05[a]	<.001[a]	<.001[a]
1 vs. 5	NS[a]	NS[a]	<.01[a]

[a]one-tailed probability.